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SPECTRAL MEASUREMENT OF WATERSHED COEFFICIENTS IN THE SOUTHERN GREAT PLAINS

Principal Investigator:
Bruce J. Blanchard
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College Station, Texas 77843

April 1976
Type II Report for Period
December 1975 - February 1976

Prepared For:
Goddard Space Flight Center
Greenbelt, Maryland 20771

Contract No. NAS5-22534

TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS

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TABLE OF CONTENTS

1.0 BACKGROUND & SUMMARY

1.1 Background

This investigation is directed toward testing and modifying a technique developed in a previous study (Contract #5-70251-AG TASK #5) where a linear combination of Landsat data was related to watershed runoff coefficients. The relationship was developed and tested in a region of central Oklahoma where extensive rainfall and runoff data were available for research watersheds.

In this study the technique will be tested in two regions; one in central and east central Texas having more dense vegetation than Oklahoma, and the other in arid regions of Arizona and New Mexico where vegetation is less dense. In each region twenty watersheds will be selected on a basis of the most adequate records of rainfall and runoff. The technique will be tested in each region by developing a relationship between spectral response and runoff coefficients based on ten watersheds and then testing the prediction capability of the relationship on the remaining watersheds in that region.

It is expected that by testing the technique in regions having more dense and more sparse vegetation on the watershed surfaces, an estimate can be made of the

area where the technique is applicable. At the same time, the influence of the quality of rainfall and runoff data used to calibrate the prediction scheme should indicate whether the technique can be useful to practicing hydrologists.

1.2 Summary

Hawkins K average curve number and Williams curve number were calculated for selected watersheds located in the eastern half of Texas. Each of these three constants can be used as watershed runoff coefficients. Hawkins K values appear to represent differences in watersheds runoff for large storm events better than average or Williams curve numbers. The Williams curve number appears to give best results when calculating monthly or annual flow from watersheds. These values were tabulated for 22 test watersheds.

A list of potential Landsat scenes was obtained from EROS Data Center that covered an area of Texas where the test watersheds were located. An extensive search of Landsat scenes on microfilm was also conducted using the Remote Sensing Center browse library facility. Usable Landsat scenes for the areas of interest had to be for dry periods during the dormant season with little or no cloud

cover. Computer compatible tapes (CCT's) were ordered from scenes that covered two or more watersheds to keep the number of CCT's ordered to a minimum.

Several combinations of Multispectral Scanner (MSS) band 5 and band 7 were used in order to produce greymaps from CCT's that would enhance the main stream and its tributaries to identify the watershed. It was found that a combination of MSS band 5 plus band 7 enhanced the stream channels best.

Watershed boundaries were delineated on the greymap by first outlining the watershed boundary and stream channels on 7.5 minute U.S. Geological Survey (USGS) maps. The USGS scale was expanded 1.072 times in the cross-track direction and compressed by a factor of 0.964 in the along-track direction. The maps were then used as a direct overlay on the greymaps to define boundaries.

2.0 ACCOMPLISHMENTS AND PROBLEM AREAS

2.1 Accomplishments

Storm runoff data and associated rainfall data were tabulated for approximately 20 storms from available records for selected watersheds located in the eastern half of Texas.

A study was made of the latest techniques for modifying the Soil Conservation Service (SCS) runoff model. A proposal has been made by Hawkins (1) for the modification of the runoff equation by allowing the runoff coefficient to become smaller with larger storms. Hawkins concept has considerable merit when using the SCS equation to determine runoff from large single events. His technique required a coefficient K that in turn determines the effective curve number for a particular size storm rainfall.

The SCS equation is being used in another fashion in the southwestern states by Williams (2) to determine runoff characteristics of a watershed by fitting a curve number to available daily rainfall and monthly runoff values. Curve numbers determined in this way tend to represent the value that can best estimate the monthly or annual yield instead of runoff from a major storm. For the purposes of this study it was deemed advisable to calculate averages of curve numbers from individual major storm events, the Hawkins K value and the Williams curve number.

Hawkins K average curve numbers and Williams curve number (Table 1) were calculated from the data available for each watershed. Test watershed locations

Table 1. Curve Numbers For Texas Test Watersheds
Landsat II Study

Watershed and Identifying Number		Drainage Area (mi^2)	Hawkins K For 7" Rainfall	Average Curve Number	Williams Curve Number
1.	Elm Fork	46.0	0.44	56.44	77.96
2.	Bois d'Arc Cr.	72.0	0.67	74.33	80.80
3.	Little Elm Cr.	75.5	0.65	72.78	78.06
4.	Honey Cr.	39.0	0.59	68.11	82.17
5.	North Cr.	21.6	0.45	57.22	69.69
6.	Big Bear Cr.	29.6	0.53	63.44	73.50
7.	N. Fork Hubbard Cr.	38.4	0.36	50.22	64.98
8.	Rabbit Cr.	75.8	0.55	65.00	75.61
9.	Green Cr.	46.1	0.34	48.67	64.82
10.	Mukewater Cr.	70.0	0.34	48.67	69.56
11.	Middle Bosque R.	182.0	0.42	54.89	75.63
12.	Tehuacana Cr.	142.0	0.60	68.89	71.82
13.	Deep Cr.	43.9	0.34	48.67	64.77
14.	Cow Bayou	85.0	0.41	54.11	75.98
15.	S. Fork Rocky Cr.	34.2	0.28	44.0	76.08
16.	Berry Cr.	81.8	0.34	48.67	77.64
17.	N. Elm Cr.	48.6	0.62	70.44	75.87
18.	Little Pond Cr.	22.2	0.69	75.89	75.45
19.	S. Fork San Gabriel R.	127.0	0.37	51.00	79.27
20.	Cibolo Cr.	68.4	0.42	54.89	74.08
21.	Lavaca R.	108.0	0.53	63.44	76.06
22.	Calaveras Cr.	77.2	0.27	43.22	60.86

are shown in Figure 1 (with identifying numbers). From the 27 watersheds initially selected, five were deleted either due to insufficient data or due to the fact that an additional set of tapes would be required to examine only one watershed.

Dry periods during the dormant season (October-March), were determined from antecedent precipitation index (API) values for the test watersheds. A request was submitted to EROS Data Center for a geographic computer search of Landsat imagery covering a rectangular area in Texas where the selected watersheds were located. Percent cloud cover, Multispectral Scanner (MSS) data quality ratings, and time of year representing dry, dormant periods were the criterion identified on the request for a geographic computer search of Landsat data. A computer print-out listing of 98 potential Landsat scenes were received from EROS Data Center. API values were calculated to ascertain dry periods during the dormant season. Since it took several weeks to receive the geographic computer search data of Landsat imagery from EROS Data Center, Remote Sensing Center (RSC) personnel also evaluated time of year, MSS data quality ratings from NASA catalogs, and percent cloud cover from microfilm images to select

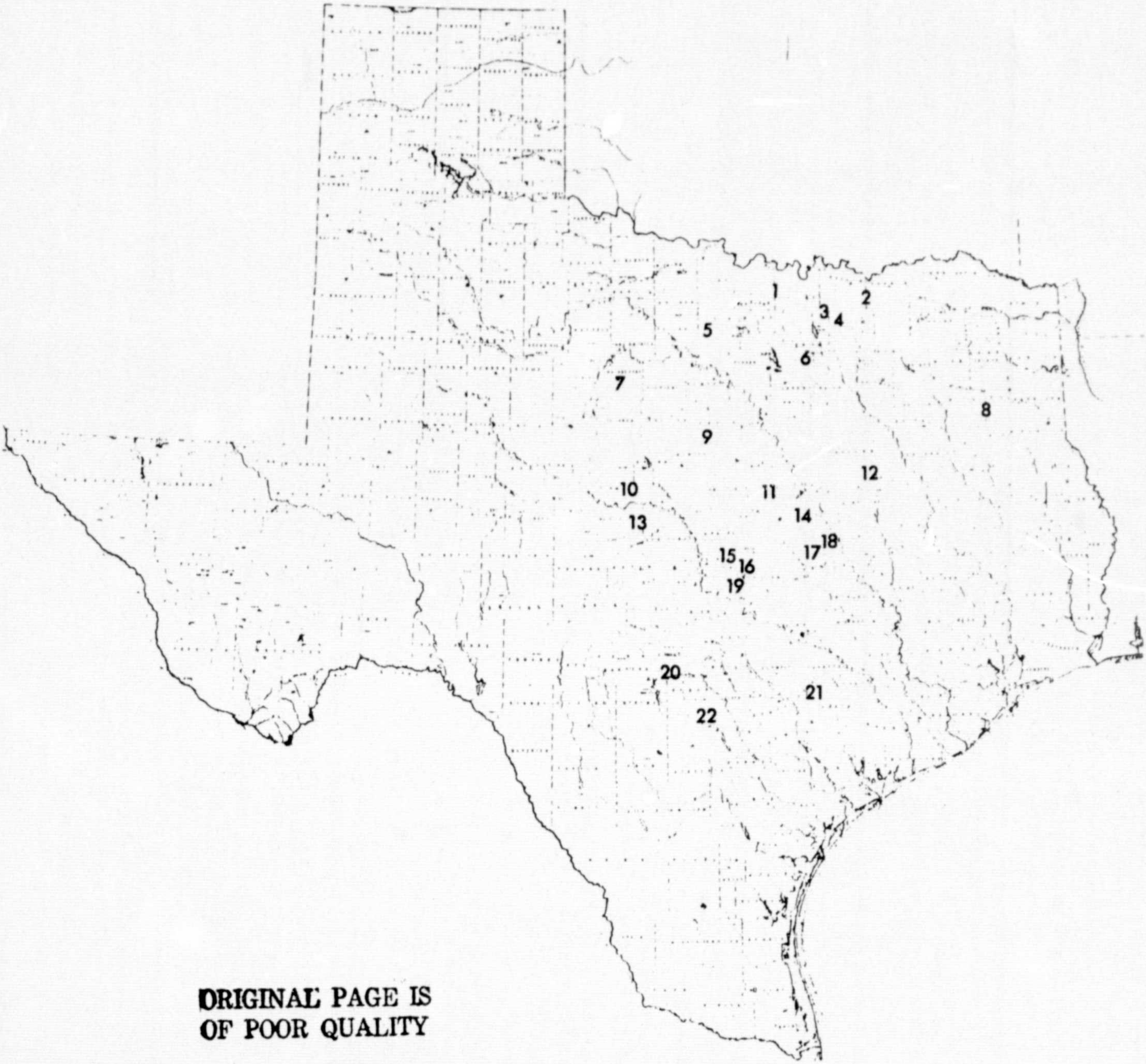

Figure 1. Location of watersheds with adequate records for use as Texas test sites.

satisfactory Landsat 1 and 2 coverage of the desired watersheds. The method of Landsat imagery search performed by RSC personnel was very time consuming. It was desirable to identify scenes that covered two or more selected watersheds and satisfy the dry period, dormant season, and percent cloud cover criterion. In order to keep to a minimum the total sets of CCT's required for the Texas portion of the watershed study, scenes that covered only one watershed were discarded when possible. Landsat-1 CCT coverage of six watersheds was available in the Remote Sensing Center tape library. Nine additional sets of CCT's were ordered from EROS Data Center to cover the remaining watershed areas.

Procedures were developed to greymap an area containing a watershed and to delineate the watershed boundaries on the greymap. This was done on a watershed for which CCT's existed in the RSC tape library. Twenty mile by twenty mile greymaps of a test watershed were printed by the computer using different combinations of MSS bands 5 and 7 to enhance the main stream, its tributaries, and water surfaces so that the watershed could easily be discerned. A combination of MSS band 5 plus band 7 showed stream channels best. Water

bodies were denoted on the greymap by the symbol W. To make sure W's were actually representing water, a portion of a lake was greymapped to determine values in band 7 that fell on water.

Satisfied with the greymapping procedure, it was then desirable to outline the watershed on the greymap. since the greymap scale was approximately the same as USGS 7 1/2-minute quadrangle topographic map scale, it was assumed the watershed boundaries could be delineated directly onto the greymap by using the topographic map as a base after aligning it with the satellite flight direction. The topographic map scale had to be expanded 1.072 times in the cross-track direction and compressed by a factor of 0.964 in the along-track direction. To do this, the watershed boundary and identifying objects, such as roads and road intersections, were outlined on graph paper from USGS 7 1/2-minute topographic maps after aligning the y-axis of the graph paper with the satellite flight direction. The angle of rotation used was 13.25 degrees. A reference datum was established, and xy Cartesian corrdinates were selected on the watershed boundary and for any identifying objects. These points were corrected by multiplying the abscissa by 1.072 and the ordinate by 0.964. The new coordinates

were plotted and the watershed boundary and identifying objects were again delineated. This new map of the watershed fits the greymap scale adequately.

2.2 Problem Areas

None

2.3 Recommendation

None

2.4 Accomplishments Expected During the Next Quarter

A computer program will be developed that utilizes trapezoids to approximate the watershed area to determine the average spectral reflectance of the individual watersheds. Average reflectance values for the four bands of MSS will be determined for the Texas watersheds. Another computer program will be developed to orient the north-south axis of the USGS 7 1/2-minute quadrangle topographic map to the flight direction of the satellite swath. This program will transform watershed latitude and longitude boundary points into records and pixels by using three reference points. Hopefully, this will make delineating watershed boundaries on the greymaps convient.

Rainfall and runoff data for test watersheds in Arizona and New Mexico will be collected and tabulated. Watershed boundaries will be outlined on USGS 7 1/2 and 15 minute quadrangle topographic maps.

3.0 SIGNIFICANT RESULTS AND PRESENTATION

3.1 Significant Results

None

3.2 Presentations

None

4.0 FUNDS EXPENDED AND LANDSAT DATA STATUS

12

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REFERENCES

[1] Hawkins, H. H., "Improved Prediction of Storm Runoff in Mountain Watersheds," *Journal of the Irrigation and Drainage Division*, ASCE, Vol. 99, No. IR4, pp. 519-523, December 1973.

[2] Williams, J. R., "Water Yield Model Using SCS Curve, *Hydraulics Journal*, ASCE, in press.